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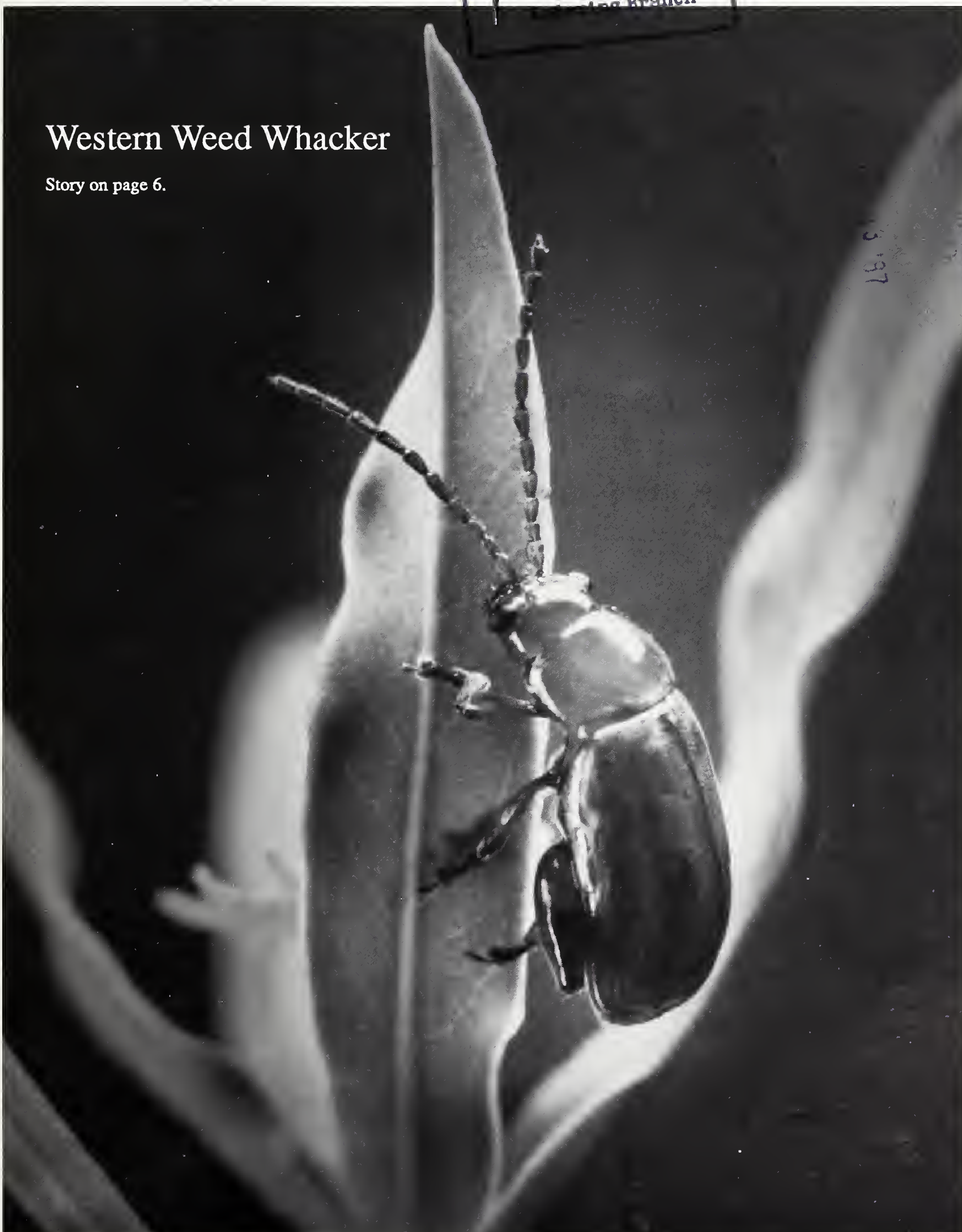
Agricultural Research



Western Weed Whacker

Story on page 6.

Our Place in Science

Better and more efficient plants and animals—in terms of growth, disease and pest resistance, flavor, and nutritional qualities. These are among our goals in the Agricultural Research Service. This is our place in science.

It's a challenging and dynamic place. Recent breakthroughs in research are often outdated by the time they're published. With public support, sound scientific inquiry, and a strong base of fundamental research, we'll continue making progress.

Our research on the biomechanisms that regulate plant and animal growth and development—the activity of genes, hormones, enzymes, and the like—will help us more thoroughly understand the biology. It will help us find the answers that are now just out of our grasp.

Do the biological materials we work with have the potential for bringing about new mechanisms? Can we remove the biological blocks that resist change? How can these biomechanisms help American farmers and ranchers become more efficient?

In the past, we could have answered these questions in the quiet of our laboratories. The public wasn't overly concerned with what agricultural scientists were doing because they were improving plants and animals in ways that farmers have been doing for millenia.

Times have changed. Moving genes from one kind of animal to another or from plant to bacterium is news, and a growing segment of our society wants to know exactly what it is we're doing. There are ethical and social concerns—concerns over animal rights, uncertainty about economic consequences, fears about scientists "playing God" in creating new or greatly altered species.

These concerns don't mean that we should slow down our scientists, but we must keep informing the public about the methods and results of our research. In the end, opinion from an informed public will lead to laws and regulations that we're going to have to live by.

Beyond all this, however, there's another kind of social consideration. What would we do in the case of a major drought or a major outbreak of disease—of plants or animals—that threatened or reduced our food supply? As scientists, we have an obligation to pursue every means of maintaining agricultural production while protecting the environment and our soil and water resources. To do that, we have to use every tool at our disposal.

Biomechanisms are among our most important new tools. They are safe, and they are essential to our international trade. Let me elaborate:

• The process is different, but the results are often the same. In our laboratories, we are doing little more than nature can do. We're just doing it faster and more precisely. As one of our scientists put it, "You no longer have to *hope* for the best, you can *pick* the best."

That said, we must acknowledge that we *are* doing some things differently. We are using genetic information from animals in plants and vice-versa. This is new. And because it is, there are people who see it as a threat to the environment. Yet I reiterate: Research using these biomechanisms is stringently controlled and safe.

• If we don't do it, somebody else will. We're in a technological race with the rest of the world. You can bet your last dollar that America's trade competitors know about genetic engineering and that they're planning to use it to develop better products. It's in our national interest to stay ahead of the competition, and the competition is fierce.

Our current situation brings to mind an old business axiom: "If you don't make dust, you eat dust." The more we do in biological research in this country, the more control we'll have over the outcome.

The research has already produced good, practical results. A small sampling:

• A new way to extend the life of turkey semen, making artificial insemination of turkeys more efficient;

• Injection of turkey eggs with biotin to improve the hatching rate;

• Insertion of genes into swine and sheep to produce leaner animals; and

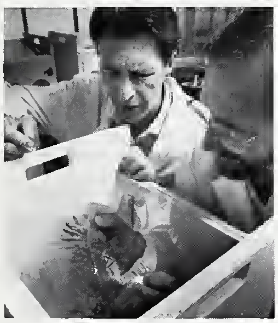
• Development of fruits and vegetables that ripen more slowly and thus have a longer shelf life.

I firmly believe that our best course of action is to continue producing the best agricultural research we can. Certainly, that includes the new biomechanisms.

Terry B. Kinney, Jr. Administrator
(Adapted from the keynote address at the opening session of Beltsville Symposium XII: "Biomechanisms Regulating Growth and Development: Keys to Progress," May 4, 1987)

Agricultural Research

Tiny (1/8th inch long) flea beetle, *Aphthona flava*, on leafy spurge is one of several biological control agents being tested to combat a costly weed that infests 2 1/2 million acres of rangeland and pastureland in the Great Plains. Article begins on page 6. Photo: Noah Poritz. (PN 7241)



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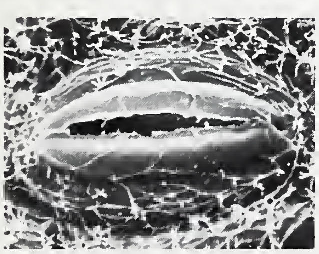

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DEPARTMENTS

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Keeping Bad Things Out of Corn

As scientists learn how the fungus *Aspergillus flavus* makes its way into corn before harvest, they come closer to understanding how to prevent its toxin from contaminating grain.

A bane to humans and livestock, aflatoxin is a natural poison and suspected carcinogen produced by several different molds, most commonly *A. flavus.*

Scientists have long thought of corn earworm larvae as major carriers of *A. flavus.* But now, Donald T. Wicklow, a USDA Agricultural Research Service microbiologist in Peoria, IL, says that often these larvae may merely pave the way for fungus infestation.

Common soil-inhabiting beetles, called picnic or sap beetles, can also play a role by carrying the fungus from the soil to corn ears. In field studies, Wicklow and University of Illinois ecologist John Lussenhop, found the beetles were attracted mostly to ears damaged by the corn earworm.

Because *A. flavus* is prevalent in crop residues the beetles feed on, a partial solution to aflatoxin contamination may come through management of crop residue in the soil. Wicklow says ongoing studies are designed to show how cultivation, as well as geographic location and soil type, affects *A. flavus* overwintering. And other studies may show whether insects are essential for grain to become contaminated with the fungus.—By **Ben Hardin,** ARS.

Donald T. Wicklow is in USDA-ARS Mycotoxin Research at the Northern Research Center, 1815 North University St., Peoria, IL 61604. ♦

To determine if picnic beetles are carrying toxic molds, microbiologist Don Wicklow transfers beetles from overwintered corn to petri dishes containing a fungal growth medium. (0487X379-16)

Unusual Iron-Fiber Combo in Soy Hulls

A mystery involving dietary iron in the coating of the soybean seed is now solved. And the solution might prompt the commercial use of soybean hulls to fortify breads and other baked products with more iron and fiber at less expense than ever before.

"The iron in the hulls is iron II," says Joseph A. Laszlo, a biochemist with the Agricultural Research Service in Peoria, IL. "As far I know, this type of iron has never been found before in plant products with high levels of fiber."

Iron II is iron in an intermediate state of oxidation comparable to mild rust. It's generally found in meat and is readily digestible. Most iron in high-fiber plants is iron III, which signifies oxidation to the fullest extent possible. Such iron combines with plant fiber and is difficult for humans to absorb. "Finding iron II in plant fiber," says Laszlo, "instead of iron III, is something like walking through a junkyard and coming across a '57 Chevy without any rust on it. But this discovery is different because it explains something not previously understood.

Specifically, it explains why soy hulls—the seed coats usually marketed for their high fiber content—are an excellent source of digestible iron as well as fiber.

"Even though the iron and fiber are mixed together in the soy hulls," Laszlo says, "it's now clear that iron in the iron II state is readily extracted and dissolved by acids in the digestive system. That's rare among minerals, especially iron, in high-fiber foods."

Indeed it is. Undigestible plant fiber or roughage, although essential to the diet because it provides bulk for the efficient movement of food through the intestines, tends to tie up minerals like iron and drag them out of the digestive system. Scientists believe that the mineral and fiber components of most plant products are bound together through ionic attraction, a kind of molecular magnetism which in effect seals the minerals against digestive juices.

"But that's not the case with iron in soybean hulls," says Laszlo. "Apparently, the attraction between iron II and fiber just isn't strong enough to keep the iron from being absorbed in the gastrointestinal tract."

Laszlo also found that soy hull iron could withstand high temperatures without jumping to the iron III state of oxidation. This means that hulls could be an extra source of iron in baking flours and doughs.

"This reinforces previous findings," says Laszlo, "with volunteers in nutrition studies who ate baked goods that had soy hull fiber in the dough. These people had iron in their blood that came from soy hulls."—By **Steve Miller,** ARS.

Joseph A. Laszlo is in USDA-ARS Food Physical Chemistry Research, Northern Research Center, Peoria, IL 61604. ♦

New Test for a Livestock Killer

A new test has been developed to detect heartwater, a disease that could threaten farm animals if it enters the United States. The disease, caused by a microbe and spread by ticks, does not affect humans but can kill livestock.

"The experimental test is the first practical blood test for heartwater and is a step toward an effective vaccine,"

says Charles A. Mebus, chief of the USDA Agricultural Research Service's Pathobiological Research Laboratory near Long Island, NY. "It has been used to check livestock in the Caribbean area."

Originating in Africa, the disease has become established on three Caribbean islands about 300 miles southeast of Florida. It is one of the worst diseases of farm animals in Africa.

Heartwater is named for one of its signs—a fluid buildup in the heart cavity.

"Infected animals can be effectively treated with the antibiotic tetracycline," he says, "but many die because diagnosis is difficult."

The disease is caused by a rod-shaped organism called rickettsia, which is a member of the family that also causes typhus and Rocky Mountain spotted fever. Heartwater is transmitted by ticks of the genus *Amblyoma* and attacks organs such as the brain, heart, and lungs.

Crucial to the test's development was the researchers' discovery in 1986 that the rickettsia grows in certain white blood cells, called neutrophils, whose normal function is to fight disease.

Most of the work was done by veterinarian Linda L. Logan, formerly with ARS. She is now with the International Laboratory for Research on Animal Diseases, Nairobi, Kenya.

"Once we found that this rickettsia *(Cowdria ruminantium)* was present in neutrophils, we developed a system for culturing it in white blood cells from goats, which gave us enough to use in a test," says Logan.

In the test, serum from an animal is applied to rickettsia-infected neutrophils. Any heartwater antibodies present become attached to the rickettsia. These antibodies are then detected by other antibodies that have been marked with a fluorescent dye.

Several species of *Amblyoma* ticks occur in the United States. They live off the blood of a variety of small animals—some birds and rodents—as well as large animals such as deer, and cattle, goats, pigs, and sheep.

Livestock bitten by infected ticks become sick in 1 to 2 weeks. Symptoms include weakness, loss of appetite, trembling, a wide stance, and a paddling motion of the legs when lying down. Animals that survive recover in about a month.—By **Vince Mazzola**, ARS.

Charles A. Mebus is at the USDA-ARS Pathobiological Research Laboratory, P.O. Box 848, Greenport, NY 11944. ♦

The Cicadas Are Here

It wouldn't be hard to make this story sound like a science-fiction script.

"After 17 years, those flying things have come back, with their red eyes and black bodies and reddish legs and orange veins and loud buzzing. Superstition had it that the distinct black 'W' on their wings foretold war."

But they're not really all that threatening. This spring—May and June—marks the return in the Northeast of the nation's largest brood of periodical cicadas, often misnamed 17-year locusts.

But that's a bum rap for the cicada, says Douglass R. Miller, of USDA's Agricultural Research Service. Locusts, he says, are species of grasshoppers that devour foliage; about all a cicada will do besides sing is to prune the tips of branches on some trees and shrubs.

Nevertheless, localized damage caused by 17-year cicadas can sometimes be severe, particularly to oaks, dogwoods, and fruit trees. The damage depends on the number of cicadas in an area.

The female damages trees when she punctures the bark of small branches to lay her eggs. The puncture wounds also allow microbes to enter the tree and rot the wood. Damage to small trees and shrubs can be reduced by covering them with open-weave cloth, such as mosquito netting or heavy cheesecloth. The cloth should be taken down only when most insects have gone.

Different broods of 13-year and 17-year periodical cicadas appear every year in parts of the East and Midwest—from the Atlantic coast to Kansas and from the Gulf of Mexico to Canada. Each brood is designated by a Roman numeral. Brood X, which will emerge this year, is by far the largest and most extensive. It last emerged in 1970 and after this year will not show up again until 2004.

Cicada, *Magicicada septendecim*, about 1-1/2 inches long. ©Grant Heilman Photography.

After an immature cicada emerges from the soil, it climbs the nearest tree or post and sheds its skin, mating within a week. (Children often find the hollow skins and hang them on their T-shirts.)

About 2 weeks later, the females lay their eggs. The adults die a few weeks after that, ending the swarm. After 6 to 8 weeks, the eggs hatch and cicada nymphs drop or crawl to the ground. They enter the soil to begin the long, slow transformation until they mature 17 years later.

"More than anything else, cicadas are interesting. I sometimes take out my flashlight late at night and watch the immatures emerge and shed their skins," says Miller. "Or I just sit on the patio and listen to their song."—*By Jim Benson, ARS.*

Douglass R. Miller is in USDA-ARS Systematic Entomology Laboratory, Bldg. 003, Room 4, BARC-West, Beltsville, MD 20705. ♦

Ranchers Battle Leafy Spurge

A knee-high weed with small greenish-yellow flowers is competing with useful grass and range plants in the northern Great Plains.

And so far, the weed is winning. Fast growing and hardy, spurge was first brought—unintentionally—to America from Europe or Asia about 100 years ago, but no one knows exactly when or how.

Today, it infests some two and a half million acres. To farmers and ranchers, spurge means an estimated $20 to $30 million in losses each year in forage and beef production, along with the costs of chemical control.

The worst outbreaks are in Minnesota, North Dakota, Montana, Nebraska, South Dakota, and Wyoming, where the deeply rooted weed crowds out desirable plants. In Montana, it ranks second among the state's top 10 worst weeds (spotted knapweed is first).

Spurge grows to be 1 to 3 feet tall, and has long, usually pointed leaves. In spring, it puts out small, bright green-yellow flowers. The plant isn't "woody" but instead is pliable; if punctured or torn, it puts out a milky white sap called latex.

On farmland, repeated spraying and plowing will keep spurge under control. But on pastures and grazing lands, these tactics can cost frustrated cattle ranchers much more than the profit their land produces. An example: In Wyoming, it can cost $100 an acre to control it on rangeland that may bring in only $10 an acre in profit for a year.

Although the weed is tolerated by sheep (they in fact do quite well on it, in some instances), this is small consolation to ranchers whose investments are tied up in cattle. Cattle avoid the plant. They may not even graze on good plants if spurge is near.

The approach that Agricultural Research Service entomologists Robert W. Pemberton and Norman E. Rees are taking to get ahead of spurge is to import a small, hardworking army of insects that are its natural enemies. If these insects adapt to their new home, they may someday be able to bring the thick stands of the weed under control simply by eating spurge leaves, burrowing into its stems and roots, or in other ways weakening the plant.

In their homelands—Italy, Hungary, Switzerland, and other countries—each of these specially selected insects may play a role in keeping spurge in check. "These insect species are probably one of the reasons why they don't have the same problem that we have here,"

BRUCE FRITZ

In a leafy spurge infested area in the mountains surrounding Bozeman, MT, entomologist Norman Rees counts biocontrol insects. In background are cages where herbicides are tested for effects on beneficial insects. (0886X1008-4)

BRUCE FRITZ

Right: Four-inch-long caterpillar of spurge hawkmoth, *Hyles euphorbiae,* eats leaves and flowers of leafy spurge, hampering the plant's ability to store food and reproduce. (0886X1006-33A)

Leafy spurge means $20 to $30 million in losses to farmers and ranchers each year.

explains Rees, who is at the Rangeland Insect Laboratory in Bozeman, MT.

The idea of using one natural organism to check or destroy another—a concept known as biological control—is not new. And it works. Pemberton, who is with the Biological Control of Weeds Laboratory in Albany, CA, gives these two northern California examples: A tiny beetle and the cinnabar moth were brought in to control tansy-ragwort, a daisylike weed that's poisonous to horses. "Today you have to look hard to find any significant numbers of tansy-ragwort in northern California," Pemberton says. Another insect, the Klamathweed beetle, was brought in to control Klamath weed. This plant grows 2 to 3 feet high has bright yellow, star-shaped flowers and crowds out desirable forage species. The beetle was so successful that local ranchers erected a bronze monument in Eureka, CA, in honor of the insect.

Biological control offers the advantages of a natural and effective way to attack weeds. Once a healthy population of the weed's insect enemies is established, letting the insects do the job may cost less than using chemicals or mechanical methods, such as plowing.

"A population that is self-propagating will maintain itself without any cost to us," Pemberton says. "That's the best case, of course. In other situations, you might have to bring in new supplies of insects periodically. But it's not like using herbicides, which you have to apply all the time."

The current lineup of promising natural enemies of spurge ranges from a plump, garishly colored caterpillar to a tiny, sprightly beetle. According to Pemberton, these insects include:

• A midge *(Bayeria capitigena)* that Pemberton says "can do a lot of damage for its size." The small fly causes tumorlike galls to form when its larvae (wormlike stage) eat the nutrient-rich growing tips of spurge. The midge can kill these tips, stopping the plant's growth as well as its production of seed. The insect looks something like a mosquito and was imported from northern Italy.

• A small, black-and-reddish-brown borer from Hungary and Italy *(Oberea erythrocephala)*. In its adult stage, this beetle punctures the plant's stem and inserts eggs. The larvae that later hatch from these eggs bore farther down the stem into the roots, where they continue their gradual development into the adult beetles. The borer uses up the plant's carbohydrates stored in the roots.

• A shiny, orange-and-brown flea beetle from Italy *(Aphthona flava)*. In its larval stage, this beetle eats roots and root hairs. When damaged, roots can't bring in needed water and minerals. The flea beetle can easily escape from enemies such as ants by simply hopping away from them.

A close relative, *Aphthona cyparissiae* from Austria and Hungary, was imported into the United States in 1986.

• The spurge hawkmoth, from Austria, Italy, and Hungary *(Hyles euphorbiae)*. In its caterpillar stage, this insect eats leaves and flowers, thus hampering the plant's ability to produce energy and reproduce. The plump, brightly colored caterpillar (it's red, black, yellow, and white) is about 4 inches long and has a prominent red horn on its tail. As a moth, it has a 3-inch wingspan and is described as an "impressive flier." Swiss scientists first tested this moth for use in Canada's prairie provinces.

Many of the insects come to the United States by way of the ARS Biological Control of Weeds Laboratory in Rome, Italy. In spring and summer, ARS entomologist Pasquale Pecora and colleagues carefully collect the European insects, gently removing them from

One imported beetle was so successful against a range weed that ranchers in Eureka, CA, erected a bronze monument in its honor.

Spurge Forces Switch to Sheep

For more than 40 years, the Yates family in Fishtail, MT, has raised purebred beef cattle on their land.

But today, Art Yates, 42-year-old son of the original owner, leases his range to other ranchers, who use it to raise sheep.

Making the switch from cattle wasn't easy for someone raised in the tradition of ranching Herefords. But the way Yates sees it, leafy spurge left him no choice.

"We couldn't afford to keep using chemicals on it," says Yates, who one year even went to the expense of hiring a helicopter to spread herbicide on his land. "Besides, you can't kill it."

Others would agree. Only very young plants that have a shallow root system will be knocked out by herbicide. Plants that have already put down a deep root system (spurge can send roots as deep as 15 feet beneath the soil) will simply sprout back from the vegetative buds in the root network.

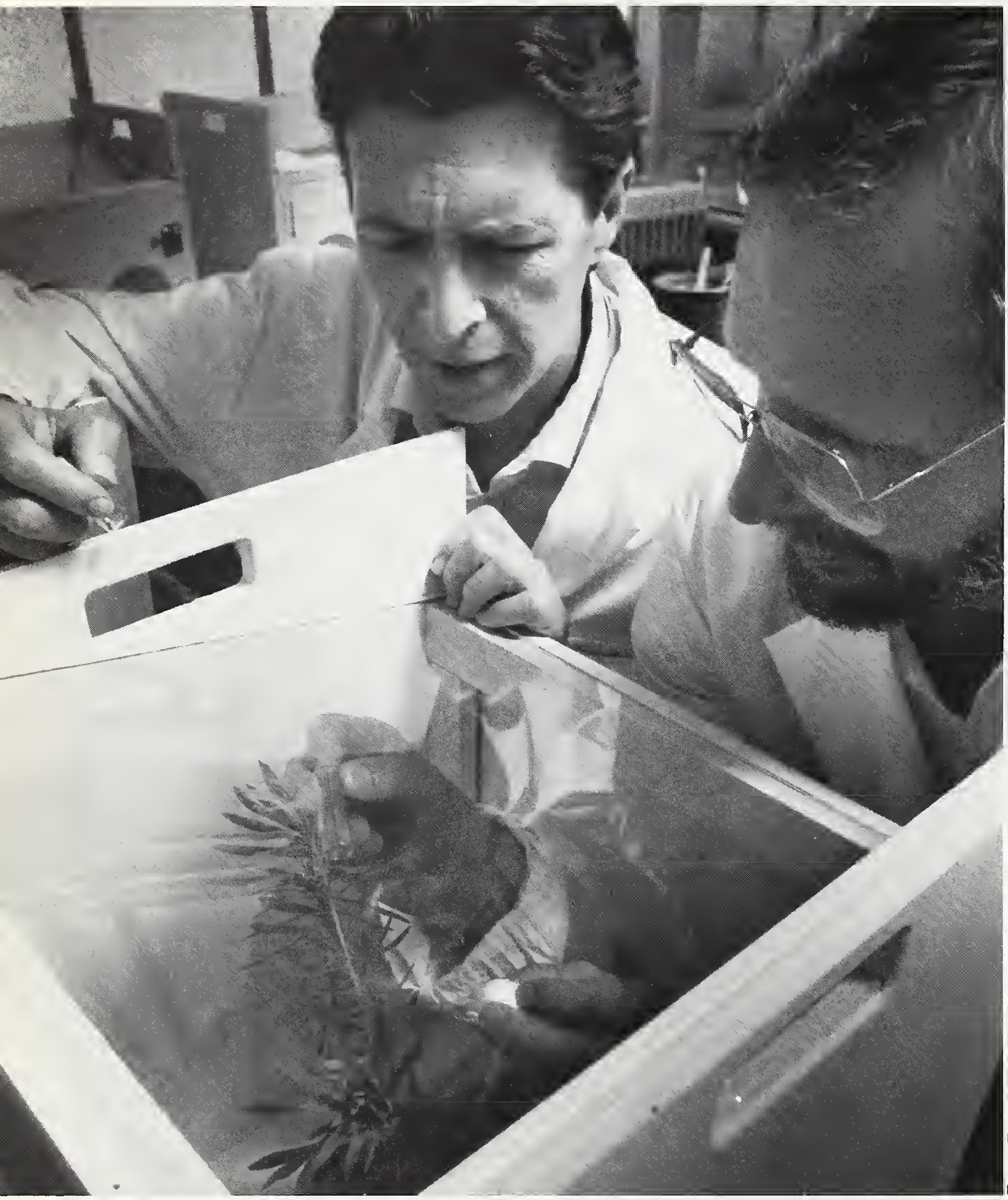
Other ranchers have tried more extreme tactics. One landowner set out with propane torches to burn the weed off his land. It worked—for a while. In 5 years, the troublesome weed was back, growing even more vigorously than before.

Research has shown that sheep raised in pastures of spurge and grass can gain more than sheep that graze on grass alone.

The picture with cattle is drastically different. "Cattle won't eat it," Yates says. "They won't even eat the grass among the spurge."

For the past several years, Yates has let Agricultural Research Service scientists release two types of spurge-eating insects—the spurge hawkmoth and the Oberea beetle—on his property.

"The place means a lot to me," he says. "I'm willing to do almost anything to get control of the stuff."—**M.W.**



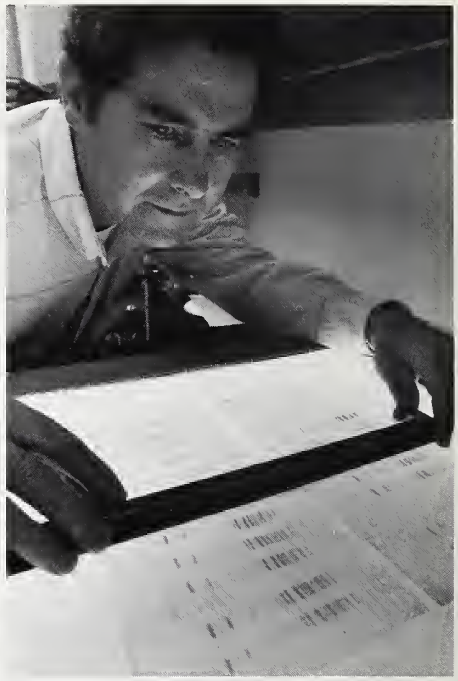
Dana Downie

At the Albany, CA, quarantine facility, entomologist Robert Pemberton (left) and biological technician Gerald Johnson release tiny flea beetles of the genus *Aphthona* on a leafy spurge plant. (0487X404-11A)

plants growing on hillsides, in valleys, or along the banks of rivers and streams.

The researchers then package the insects and air freight them to Pemberton's California laboratory. There, he closely examines the insects for disease or other problems. It is these insects—or in some cases their off-spring—that are in turn shipped to Montana, where Pemberton and Rees set them free in spurge-choked fields.

Years of laboratory and field research in Europe and laboratory work at Albany go into the selection of each insect. "None of the insects are released until we've proved that they won't inadvertently attack crops or other desirable plants," Pemberton says. For example, harmless plants that are closely related to leafy spurge get special attention. These include spurges that have been nominated for rare-and-endangered-species status and the popular poinsettia plant—another spurge relative.



Dana Downie

Differences in protein composition of leafy spurge seeds from various locales are determined through gel electrophoresis by chemist Kenneth Stevens in Albany, CA. (0487X406-17)

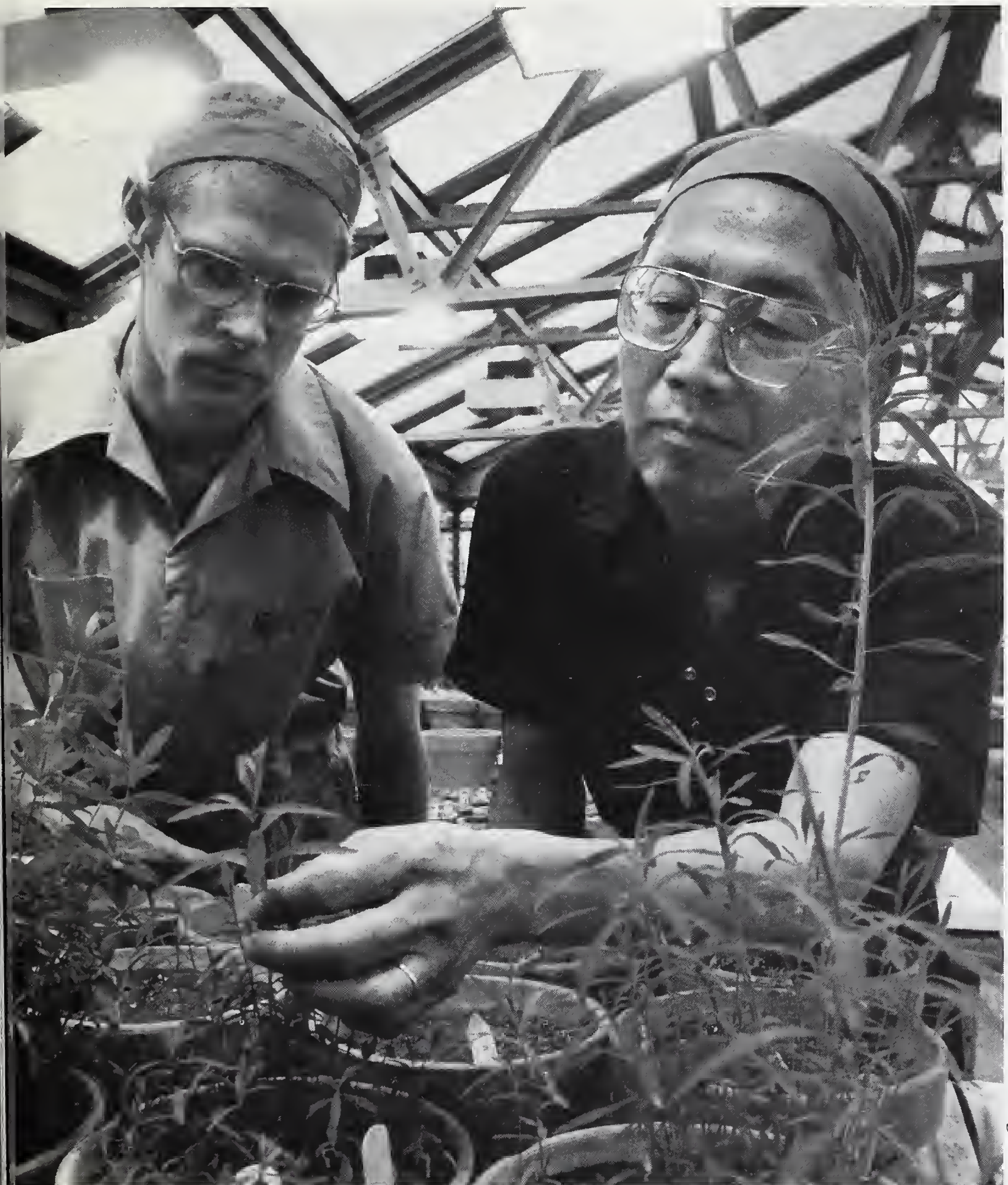
The insects, generally released in summer, aren't considered "established" until they survive the winter in their new home and produce enough offspring the following spring or summer to ensure continuation of their population. Ideally, the insects would be so abundant that large numbers of them could be collected and taken to other sites where they are needed.

Spurge's Ancestry Is Important

Spurges in this country may be highly hybridized—probably much more so than those in Europe or Asia, from which the American plants descended. Sorting out the parentage of the hybridized American spurges might help reveal their country or region of origin. This could prove useful in locating new natural enemies for potential use in America.

To the casual observer, differences among spurges of various origins might not be readily apparent. But internal differences in chemical composition might provide useful indicators of origin.

Classifying plants on the basis of the chemicals that they're made up of—instead of what the plants look like—is a



At the ARS Foreign Disease Research Unit in Frederick, MD, plant pathologists Sam Yang (right) and William Bruckart examine leafy spurge plants infected with *Uromyces scutellatus,* a rust disease that kills spurge. Yang and Bruckart are studying the rust as part of the agency's national biological control research. (0487X395-20)

field of study known as chemotaxonomy (for "chemical taxonomy"). It's proven successful in distinguishing remarkably similar yet chemically distinct varieties of sunflowers and other commercial crops.

With spurge, the most promising lead so far seems to be the differences among a unique group of chemicals known as jatrophane diterpenes, says research chemist Gary D. Manners of the Plant Protection Research Unit, Albany, CA. He has analyzed spurge from different locations (Oregon, Montana, North Dakota, and Austria) and has found distinct differences in the composition and amounts of jatrophane diterpenes. "This means that jatrophane diterpenes may be accurate and reliable indicators of different biotypes or varieties," Manners says.

Manners and David G. Davis, an ARS plant physiologist at the Metabolism and Radiation Research Laboratory, Fargo, ND, recently discovered three jatrophane diterpenes that had never before been found in leafy spurge. And Manners has come up with a laboratory process that analyzes jatrophane diterpenes in spurge in just 20 minutes. Until now, an analysis would take much longer.

For research chemist Kenneth L. Stevens, also at Albany, the chemicals of interest are proteins. His focus is on how the proteins might differ from one plant population of spurge to another.

"Chemical differences may be a reliable indicator of spurge varieties."

Gary D. Manners, ARS chemist, Albany, CA

His approach: gel electrophoresis, a laboratory technique in which a ground-up sample of seed is placed on a slab of gel, then zapped with an electrical charge that drives separated proteins to distinct locations in the gel. Stevens logs the approximate location of each protein into a computer that, in turn, can quickly point out important similarities among the protein patterns from different spurges.

Will the combined efforts of these scientists and insects pay off? "When you're working with nature, it's hard to make guarantees—especially when your target is one as difficult as leafy spurge," Pemberton says. "But because leafy spurge is such a severe problem for farmers and ranchers, it's worth the effort."—By **Marcia Wood**, ARS.

Gary D. Manners, Robert W. Pemberton, and Kenneth L. Stevens are at the USDA-ARS Western Research Center, Albany, CA 94710. Norman E. Rees is at the USDA-ARS Rangeland Insect Laboratory, Montana State University, Bozeman, MT 59717. David G. Davis is with the USDA-ARS Metabolism and Radiation Research Laboratory, P.O. Box 5674, Fargo, ND 58105. ♦

Blueberries From Field to Muffin Tin

Tim McCabe

On the family farm she manages near Starkville, Mississippi, Carol Reese picks fruit from a highbush blueberry variety that ripens in May. (0786X797-22)

When raising dairy cows and growing soybeans became unprofitable, the Reese family in northeastern Mississippi decided to try something new. In 1981, they planted 5 acres of blueberries.

"It's ridiculous to be in soybeans and dairying when you can't make a living at it," says Carol Reese, who manages what is now her family's 18-acre blueberry farm near Starkville. "Blueberries are our main crop now. They grow well in this area, and plenty of people want to buy them."

The Reeses run a "pick-your-own" operation on 8 acres—5 of the southern rabbiteye blueberry and 3 of the northern highbush. This year they added 10 more acres of highbush berries that they hope to sell to produce buyers for early season sale in the North. The highbush berries ripen in mid-to-late May, 3 to 4 weeks earlier than in the North. She says a flat of berries—10 to 12 pounds—sells for between $16 and $20 in May—twice the June price.

One reason southern growers like the Reeses—as well as growers in the North—are succeeding is because U.S. Department of Agriculture scientists, with help from state researchers and growers, have tamed the wild blueberry, which the American Indians and the early settlers once ate fresh from the plant.

In 1986, U.S. growers produced 154 million pounds of berries worth $94 million, according to the North American Blueberry Council. Last year's average price was 88 cents a pound for fresh blueberries and 48 cents a pound for those sold for processing, the council said.

"Blueberry breeding is an excellent example of how USDA, state scientists, and growers have worked together to establish an industry and help it grow," says Howard J. Brooks, horticulture expert for USDA's Agricultural Research Service in Beltsville, MD. "Ninety-five percent of the blueberries in production today were developed by our scientists, often with growers and state scientists in New Jersey, North Carolina, Georgia, and Michigan."

Since 1949, the agency has cooperated in releasing 39 blueberry varieties

that produce fruit under a range of conditions. For example, Bluecrop, released in 1949, accounts for about half the commercial blueberry acreage and is grown mostly in the North; Bluechip, released in 1979 by ARS and North Carolina, resists cane canker disease; Cooper and Gulfcoast, released in January this year, will be early ripening highbush varieties adaptable to the warm southern climate.

There are generally three blueberry types native to North America: the lowbush, a wild plant which grows from 1 to 2 feet high primarily in Maine; the highbush, usually about 6 to 8 feet tall, predominantly in Michigan, New Jersey, North Carolina, and the Pacific Northwest; and the rabbiteye, native to the South and which grows up to 12 feet high.

These wild plants had to be taken from their natural habitat in mountains or along streambeds, for example, and bred so they would grow on a modern-day fruit farm. That has been complicated because blueberries need highly acidic soils that kill most other crops, and they need a certain number of hours of winter chilling—at or below 45°F—or they won't produce enough fruit to be commercially profitable. They also have shallow roots—only about 12 to 18 inches deep—and can't tolerate drought as well as plants with deeper roots.

This has limited much of the blueberry production to states like Michigan and New Jersey, which have areas where the soil is acidic and underground water tables are high. Michigan has about 12,000 acres of fruit-bearing plants and New Jersey about 9,500. Together they account for almost two-thirds of the U.S. crop.

Art Galletta's family in Hammonton, NJ, grows 1,300 acres of blueberries on their Atlantic Blueberry Co. farm. He says it's the world's largest blueberry farm, producing from 8 to 10 million pounds a year. The Gallettas have often cooperated with blueberry researchers by planting new seedlings and growing them under commercial conditions so scientists can choose the best among the lot. Today, Galletta says, they grow about 12 or 13 types of blueberries, most developed by ARS and the New Jersey State Experiment Station.

"But we're always looking for better varieties that stay fresh longer and stand up to machine harvesting, so breeding is very important to us," Galletta says. In fact, one new ARS variety called Duke, released in 1985, is named after his father, S. Arthur (Duke) Galletta, and will be grown at the family's farm.

Despite Michigan's and New Jersey's dominance in production, farmers like the Reeses are expanding production from Arkansas and Texas east through Mississippi, Georgia, Florida, and North Carolina with the early ripening varieties. Production is also gaining in Oregon.

"We're always looking for better varieties that stay fresh longer and stand up to machine harvesting."

Art Galletta, operator of the Atlantic Blueberry Co. farm, Hammonton, NJ.

"A lot of states are looking at blueberries as an alternative crop, and new varieties are making it possible," says Arlen D. Draper, an agency plant geneticist at Beltsville who has worked on blueberry breeding since 1965. "Blueberries are well-suited to small farms because you can grow a lot of berries on 5 or 10 acres."

The potential for blueberries as a cash crop has spurred production in many areas. Annual U.S. production has jumped over 90 million pounds since 1977. Much of the new acreage has been in the South. In Georgia where there are about 3,000 acres of cultivated blueberries, there were virtually none in the early 1970's. Arkansas acreage increased to about 800 acres during the same time. Oregon increased from 450 acres in 1978 to about 1,100 last year. Mississippi has about 775 acres; up from less than 5 in 1975.

"Until a few years ago, nobody down here even knew what a blueberry was, except for some of the northerners who had moved in. Now our problem is having enough blueberries to satisfy demand," says Mississippi extension specialist John Braswell, who is also executive secretary of the Mississippi/Louisiana Blueberry Association.

Growers and industry association members credit USDA and state scientists for their breeding work. Paul Horner, general manager of the Arkansas Blueberry Growers Association, says growers groups usually can't afford to hire plant geneticists to do breeding research. And Braswell said that without the ARS Small Fruit Research Station in Poplarville, MS, "there probably wouldn't be an industry here at all."

Heading the Poplarville station is horticulturist James Spiers who, with Draper, develops varieties adapted to the South. "The new Cooper and Gulfcoast berries, for example, will help growers compete in early season markets so they can get the best price and satisfy consumer demands," Spiers says. "These varieties should be available in nurseries next year and should be producing fruit in 3 years."

Draper and Spiers are building on agency research that USDA botanist Frederick V. Coville began in 1906. Coville, working for what was then USDA's Bureau of Plant Industry, began by asking blueberry connoisseurs to provide him with the best wild berries they could find. "He put up posters with a half-inch hole and said he'd give a prize to anyone who had berries that wouldn't fit through the hole," Draper says. "That's how he got the wild varieties with the biggest fruit for breeding."

The first wild blueberry used for breeding, called Brooks, was found in 1908 growing in the mountains of southern New Hampshire. Coville took that and crossed it with a wild New Jersey blueberry called Sooy. The result was the first commercial blueberry variety, Pioneer, released in 1920. In the 1940's, Pioneer became one of the parents for Bluecrop.

Pioneer had fruit about a half-inch in diameter—large for its day. "Today that's common, and some blueberries are up to 1 inch in diameter, largely because of improved varieties through breeding," Draper says. "They also retain their flavor longer than earlier varieties. Now we're looking for plants that produce more fruit, ripen earlier, tolerate diseases, require less winter chilling, and grow in less acidic soils."

TIM McCABE

TIM McCABE

Above: Searching for an improved early season blueberry, plant geneticist Arlan Draper cross-pollinates a wild plant with one that's commercially available. (0487X343-30)

Left: Soil scientist Ron Korcak and technician Ginny Walker examine the root system of a blueberry plant to study the effects of nitrogen on root development. (0487X359-1)

In the early 1900's, Coville discovered that native North American blueberries—along with rhododendrons and azaleas—are in a class of plants that thrive in highly acidic soils with a pH of between 4.3 and 5.2 (7 is neutral). This family of plants is known as Ericaceae.

Why do blueberries like such acidic soil? ARS soil scientist Ronald F. Korcak is trying to find out. One theory, Korcak says, is that acid soils have low levels of calcium and magnesium and that blueberries need low amounts of those two nutrients. Acid soils also contain high amounts of the metals aluminum and manganese, which are usually poisonous to crops.

"Blueberries can tolerate up to 6,000 parts per million of manganese, while corn normally withstands between 50 and 200," Korcak says. "We're not sure at this point how tolerant blueberries are to aluminum, but it's being studied."

Korcak says there is potential to develop blueberry varieties in soils with higher pH's. He notes that one of Draper's crosses survived in greenhouse soil with a 6.5 pH. To study that variety's root system, Korcak grows it in glass boxes with a purple soil dye to see how the roots affect the soil environment and vice versa.

"We'd like to find varieties that are adaptable to higher pH soils so blueberries can be grown in more areas of the country," Korcak says.

Several diseases trouble blueberries but haven't seriously threatened production, probably because as a native plant blueberries have built up resistance. An exception is in North Carolina, where a fungal disease, called cane canker, damages blueberry plants by causing the bark to split. ARS, working with North Carolina State University scientists, developed several improved varieties that resist cane canker.

Aside from breeding and soil research, other ARS blueberry studies include:

• Virus-testing techniques for nursery stock. ARS scientists at Corvallis, OR, with financial support from the blueberry council, have established and successfully tested highbush nursery stock to make sure it isn't infected with virus diseases. Often, signs of these diseases aren't visible until months after the nursery stock is planted. Scientists developed virus-free clones of the major highbush varieties and distributed them to state departments of agriculture in New Jersey, Michigan, Oregon, and Washington. From there, they'll be made available to plant nurseries.

Corvallis scientists also developed a screening test for blueberry red ringspot, a major disease-causing virus that is often difficult to detect. The test takes only 1 day; previous ones took 2 to 3 days. The new test now gives growers a more practical, reliable way of detecting this disease in highbush nursery stock.

• Fighting sheep pen hill disease. USDA is funding research at Rutgers University in New Jersey to study a disease called sheep pen hill, which weakens the plant and can kill it. Scientists are trying to identify the cause of the disease and how it spreads. A similar disease, called scorch, has been found in blueberries in the Pacific Northwest. ARS scientists, in cooperation with Agriculture Canada and the Washington and Oregon experiment stations, are studying it as well.

• Flavor. Scientists at the Richard B. Russell Research Center in Athens, GA, have identified the chemicals that give rabbiteye blueberries their flavor so that it can be maintained in processing.

• Explosion puffing. Scientists at the Russell center applied this process to blueberries. Developed at the agency's research centers in Albany and Philadelphia, explosion puffing removes the water from blueberries so they can be packaged and used in processed foods or

later rehydrated. (See *Agricultural Research* July/August 1982, p. 12) Delite Foods of Alma, GA, has built a plant to use this technology and has already sold 150,000 pounds of berries for use in muffin and cake mixes.

• Quality. Scientists at the Eastern Research Center in Philadelphia have studied the effects of freezing, thawing, and cooking on highbush blueberries sold fresh or used in processed foods. They've also researched factors that affect color and composition of the berries and have evaluated different varieties to see which ones leak more juice through their skins. This helps determine which berries are best for baking.

• Export potential. At the U.S. Horticultural lab in Orlando, FL, marketing specialists have found that the Climax rabbiteye variety can withstand 2 to 3 weeks aboard a ship bound for the agency's laboratory in Rotterdam, The Netherlands. That's good news for U.S. farmers looking for foreign markets to sell their crops.—By **Sean Adams**, ARS.

Howard J. Brooks is with the USDA-ARS National Program Staff, Bldg. 005, BARC-West, Beltsville, MD 20705; Arlen D. Draper and Ronald F. Korcak are at the USDA-ARS Fruit Laboratory, Bldg. 004, BARC-West, Beltsville, MD 20705; and James M. Spiers is at the USDA-ARS Small Fruit Research Station, P.O. Box 287, Poplarville, MS 39470. ♦

Vitamin K Tests May Answer Medical Questions

A major improvement in measuring vitamin K_1—a long-neglected nutrient essential for blood clotting—could lead to a Recommended Dietary Allowance (RDA) as well as answer some unresolved medical questions about clotting and bleeding disorders.

Vitamin K_1 has been difficult to detect in the blood and therefore difficult to study, because it occurs in such tiny amounts, says James A. Sadowski, chief of the Vitamin K Laboratory at the Human Nutrition Research Center on Aging. Based at Tufts University, Boston, the center is funded by USDA's Agricultural Research Service.

With the new method, developed by chemist Yacoob Haroon, scientists can detect lower levels of the vitamin and analyze up to five times more blood samples a day than previously possible. The secret to this is zinc, which can chemically react with the vitamin.

According to Haroon, "We're at a point where we can look at the body's absorption of the vitamin from foods and study its metabolism"—the kind of information needed to set an RDA.

"Now that we've got a way to measure vitamin K_1," says Sadowski, "we're ready to start attacking several long-standing bleeding and clotting problems," such as how to balance K intake with anticlotting drugs.

Sadowski and Haroon have already established normal fasting blood levels of the vitamin—"the lowest of any fat-soluble vitamin," Sadowski says. An analysis of blood samples from 341 men and women 20 to 90 years old shows that the average concentration is a tiny one-half of one billionth of a gram per milliliter, "about one thousand times lower than vitamins A and E."

Sadowski says the highest and lowest blood levels in the study differed no more than one billionth of a gram per milliliter of blood. "That's a very, very narrow range. Some process must be controlling the levels very tightly."

The vitamin is essential for the synthesis of several proteins involved in blood clotting and for the proper functioning of certain proteins in bone and kidneys.

Plants manufacture vitamin K_1, or phylloquinone, while bacteria manufacture another form—vitamin K_2, or menaquinone. Green vegetables, liver, bacon, coffee, and tea are rich in the vitamin. Intestinal bacteria may supply some of a person's requirement, says Sadowski.

Haroon's method is more efficient at extracting the vitamin from blood, tissue, or food samples as well as at measuring it. In the presence of electrically charged zinc atoms, metallic zinc converts the vitamin into a form that dissolves easily in an extraction fluid and also fluoresces, or emits light. After the vitamin is separated from other chemicals, this emission can be detected by a fluorometer.

Nearly 95 percent of the vitamin is converted by this method compared with about 60 percent for older methods, he says. "This is a vast improvement."

The two researchers are already using the method in work with University of Vermont scientists on the interplay between vitamin K and blood anticoagulants.

The elderly have a high incidence of clotting disorders—heart disease and stroke—and are often given anticoagulants, Sadowski says. "These drugs directly counteract vitamin K. You have to balance vitamin intake with the drug."

On the other side of the coin are bleeding disorders.

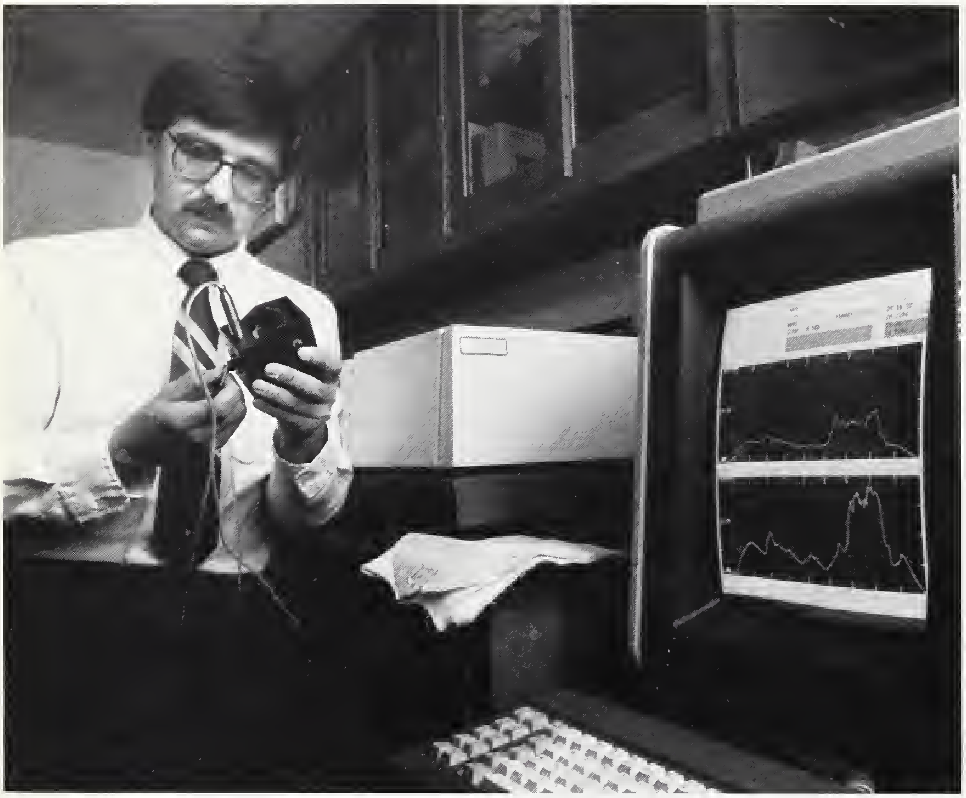
Severe unexplained bleeding is common in the elderly after an accident or surgery and is reversible by giving vitamin K injections. Sadowski plans to see if the bleeding is caused by lower reserves of vitamin K in the body.

Most infants get a shot of vitamin K at birth, and this has dramatically reduced deaths from hemorrhage after birth. But a small proportion of infants run a high risk of brain hemorrhage during birth because of poor prenatal care.

"A shot of vitamin K at birth probably does little good for these high-risk babies. The damage, which may lead to retardation, has already been done." His research group has proposed a study to the National Institutes of Health that will attempt to get the vitamin into the fetus through supplements, injections, and nutrition counseling for the mother.—By **Judy McBride**, ARS.

James A. Sadowski is at the USDA-ARS Human Nutrition Research Center on Aging, Tufts University, 711 Washington St., Boston, MA 02111. ♦

Scientists Shine New Light on Treasures of the Past



Bruce Fritz

Bombarding linen with pulsating infrared light creates a tone that tells how well the cloth has resisted deterioration from exposure to sun and air. Biochemist J. Michael Gould removes a cloth fragment after analyzing computer profile of the soundwaves. (0487X377-20)

Fragments of cloth from Egyptian mummy wrappings and ancient Indian dwellings produce revealing sounds about their past when bombarded by beams of infrared light.

"The fibers generate a steady, almost musical tone when we hit them with rapid pulses of the light," says J. Michael Gould of USDA's Agricultural Research Service, "and that tone can tell us how well the cloth has done over the centuries—how much it's been weakened by sun, air, and time."

Such knowledge, Gould says, will help textile specialists prescribe better ways for museums to preserve battle-torn flags, uniforms, clothing, and other cloth treasures of the past.

Determining the degradation of archeological relics is just one more application of a technique called photoacoustic spectroscopic analysis, which Gould, a biochemist at the ARS Northern Research Center in Peoria, IL, first used several years ago to investigate the molecular structures of lignin and cellulose in plant tissue.

"We knew that a lot of crop wastes and residues could be put to good use as feed for cattle," says Gould, "if only their lignin-cellulose bonds could be broken up beforehand. That meant we had to understand more about the structures of both molecules, especially as they existed in nature and not just in theory."

An analytical technique called photoacoustic spectroscopy offered Gould a way to get the information. The technique was highly experimental, however, and had been used mainly on minerals—rarely on organic materials such as plant tissue. Also, there was no such thing as a readymade photoacoustic spectroscopic analysis machine.

"Actually, it wasn't all that difficult to build one," says Gould. "I was able to improvise with existing laboratory equipment. Most of the theoretical work had already been done by other scientists, and I just needed to apply it."

Photoacoustic spectroscopic analysis relies on the fact that molecules will expand and contract in response to intense, pulsating light—and in so doing create specific sounds corresponding to the wavelength of the light, the light's pulse rate, and the structure of the molecule. Depending on the molecule being analyzed, sounds may be audible without amplification.

"The sound reveals a lot about the structure," Gould says, "and we don't have to vaporize, burn, or chemically alter the molecules in any way."

After analyzing computerized profiles of soundwaves from lignin and cellulose, Gould developed a chemical process to break them apart and convert crop wastes and residues into wholly digestible feedstocks.

"Once we saw the molecules in their natural state," he says, "we could deal with them."

That same view of molecules in their natural state was precisely what another scientist, Jeanette M. Cardamone of Ohio State University, needed for her studies of aging in historically valuable textiles.

"When I learned about Mike Gould's work," she says, "I realized its potential application to questions about the way air and sunlight degrade cellulose in textiles—especially natural cotton, which is a very pure form of cellulose."

Now a professor of textile science at Virginia Polytechnic Institute, Cardamone asked Gould to first analyze fragments of cotton from an Indian breech cloth, arrow quill, strap, and seed beater wrapping found at archeological sites in Arizona.

Through photoacoustic spectroscopy, the two scientists were able to identify specific molecular changes in the museum samples caused by centuries of oxidation and exposure to sunlight.

"For the first time," says Cardamone, "we had a quick and reliable way to precisely measure the amount of oxidation in cotton fibers while leaving the fibers themselves completely intact."

The signifance of this was twofold. One, it meant that precious samples of historic textiles could be continuously monitored for oxidative degradation without being harmed in the process. Equally important, knowing exactly how much a textile had deteriorated meant that a better, more customized program for its care and display could be prescribed for the future.

"We can't stop the deterioration altogether," Cardamone says, "but we can slow it down a lot through environmental treatments such as limiting exposure to sunlight and lowering the oxygen content in a display case."

Most museums already follow such procedures, of course, especially in regard to sunlight. At the Smithsonian Museum of American History, for example, the flag that flew over Fort McHenry during the War of 1812 and inspired Francis Scott Key to write America's national anthem is on view for only 3 minutes out of every hour. The rest of the time it's kept in total darkness.

"The main concern is whether the steps being taken are adequate for the real condition of the cloth," says Cardamone. "In many cases, they probably are. It's also possible that in some exhibits the protection is excessive."

To determine how long a historic piece of cloth can be displayed without jeopordizing its longevity, explains Cardamone, the condition of the cloth at its weakest point has to be known.

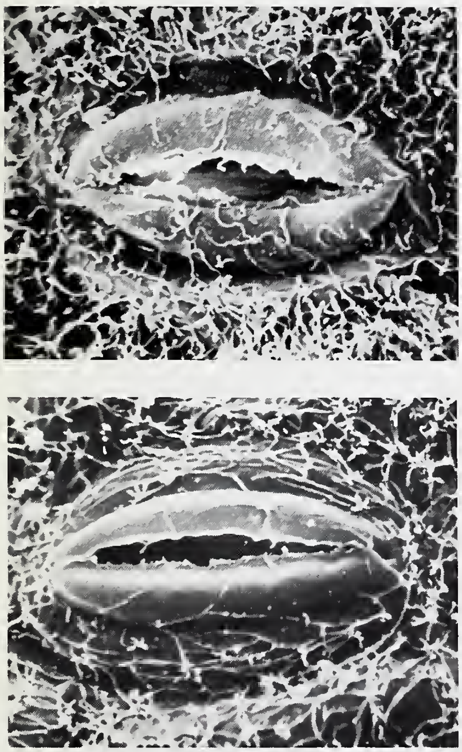
"You have to remember that the oxidation of cloth is an ongoing process," she points out. "Once it starts, it's inevitably going to spread. In cloth, however, exposure to light accelerates the process considerably." Cardamone herself has an extensive collection of fibers from ancient pieces of cloth, some of which have served as test subjects for Gould and his photoacoustic analysis machine. To further challenge the capabilities of photoacoustics as a way to determine the degradation of cellulose in cloth, the textile scientist from Virginia Polytechnic recently sent Gould some linen fibers from an Egyptian mummy wrapping over 2,000 years old.

Unlike the fragments of cotton cloth from American Indian sites and other cotton fibers sent to Gould previously, linen comes from flax which contains significant amounts of cellulose-binding lignin. Also, the mummy wrapping fibers had traces of wax and incense used in Egyptian burial ceremonies.

"We're still experimenting with different wavelengths and intensities of light," says Gould, "in order to produce sound profiles that distinguish between all of the molecular structures involved. The photoacoustic analysis of linen is a complicated process compared to cotton, and it's going to take awhile longer to get it done right."—By **Steve Miller**, ARS.

J. Michael Gould is at the USDA-ARS Plant Polymer Research Lab., Northern Research Center, 1815 North University St., Peoria, IL 61604. ♦

Fingerprinting Roses



Scanning electron micrographs reveal distinctive differences between stoma (leaf opening for breathing) of the Spellbinder rose (top, PN-7232) and stoma of the Color Magic rose (PN-7234). Magnified 1,700 times. SEM's by Charles Krause.

Why "fingerprint" a rose? Answer: to protect it from piracy.

Here's the story. New hybrid varieties of rose can be patented, entitling the patentee to royalties from nurseries that grow and sell his or her creation. Consumers now pay from $4 to $20 for a patented rose plant, depending on the variety.

Unfortunately, pirating patents in the rose game is anything but rare. All that rose pirates have to do is buy a popular hybrid, snip off some cuttings, root them, and they're in business. With hundreds of hybrid varieties on the market, it's often difficult for patent holders to prove in court that a particular rose is theirs.

Now, however, a U.S. Department of Agriculture scientist in Ohio has found a way to identify each variety of rose with a high degree of certainty.

Charles R. Krause, a plant pathologist with the Agricultural Research Service, used a scanning electron microscope to magnify the leaves of rose varieties as much as 20,000 times. When he did, he found marked differences among varieties in the shape of leaf openings, called stomata on leaves and thorns.

Photographs of the distinctive openings can serve as "fingerprints" to settle questions of patent ownership easily.

"For the first time," says Krause, "we can accurately distinguish one rose variety from another."

The researcher has started the fingerprint file with photos of 20 hybrid varieties, including South Seas, Antigua, Color Magic, Spellbinder, and Promise. He has also written a fingerprint manual.

Krause emphasizes that using the electron microscope to identify plant varieties is not limited to roses.

Is plant piracy really that common? Judging by the volume of mail that Krause has received from all over the world since first reporting his discovery, it is. A major Israeli exporter of new breeds of roses, carnations, and other flowers wrote that "the more we develop, the more we are pirated."

Thanks to Krause, maybe gardening won't be such a dirty business from now on!—By **Hubert Kelley**, ARS.

Charles R. Krause is in the USDA-ARS Nursery Crops Research Laboratory, 359 Main Rd., Delaware, OH 43015. ♦

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PATENTS

Natural Herbicides

With a little design help, Nature may be able to produce a new line of selective, safe, and biodegradable herbicides.

Agricultural Research Service scientists are redesigning some fungal byproducts into compounds (patent pending) that promise to kill important weeds—barnyardgrass, morningglory, and wild mustard—without harming corn or soybeans.

The byproducts being changed are cyclic peptides of four amino acids, already known to kill weeds without harming crops. Contrary to expectations, scientists found that a simpler synthetic version, with three amino acids linked in a linear chain, also has herbicidal potential. The new tripeptide inhibits root and shoot growth of agronomically significant weeds. This differs from the cyclic tetrapeptide it was derived from which works by interfering with chlorophyll production.

Fewer chemical reactions are required to produce the new peptidic herbicide, moving the process a big step closer to practicality. Much more remains to be done, with the possibility of simplifying the process even more or producing a cyclic synthetic alternative, before the designer herbicide ever enters the marketplace.

Preliminary tests indicate some of the new compounds also have potential as plant growth regulators, promoting as well as inhibiting root or shoot growth.

For technical information, contact Judson V. Edwards, Crop Protection Chemistry Research, USDA-ARS Southern Research Center, P.O. Box 19687, New Orleans, LA 70179. *Patent Application Serial No. 06/886,502, "Novel Phytotoxic and Plant Growth Regulating Oligopeptides."* ♦

Controlling Lesser Mealworms in the Coop

Instead of spraying insecticides on fly larvae in chicken houses to control adult flies, why not mix a safe dose of insecticide with the chicken feed?

ARS scientists are testing this technique on fly larvae that eat chicken excreta. Besides flies, another pest in chicken houses is the lesser mealworm, *Alphitobius diaperinus*. This insect in both its larval and adult stages (as beetles) prefers spilled feed to excreta.

No problem. ARS researchers have applied for a patent on five compounds that, mixed in feed in amounts as low as 1 to 2 parts per million, either kill the larva or prevent its growth to the adult stage.

Although they may transmit poultry diseases, the major problem with lesser mealworms is that their burrowing destroys insulation in modern high-rise caged layer and broiler grow-out houses.

While these additives do not appear to harm the chickens, more research is needed to determine if residues can be found in edible parts.

Additional tests required by the Food and Drug Administration would also need to be conducted before the additives could be used commercially.

For technical information, contact Richard W. Miller, USDA-ARS Livestock Insects Laboratory, Bldg. 177-A, BARC-East, Beltsville, MD 20705. *Patent Application Serial No. 06/882,104, "Control of the Lesser Mealworm."* ♦

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